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Marginal costs and co-benefits of energy efficiency investments The case of the Swiss residential sector

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Abstract

Key elements of present investment decision-making regarding energy efficiency of new buildings and the refurbishment of existing buildings are the marginal costs of energy efficiency measures and incomplete knowledge of investors and architects about pricing, co-benefits and new technologies. This paper reports on a recently completed empirical study for the Swiss residential sector. It empirically quantifies the marginal costs of energy efficiency investments (i.e. additional insulation, improved window systems, ventilation and heating systems and architectural concepts). For the private sector, first results on the economic valuation of co-benefits such as improved comfort of living, improved indoor air quality, better protection against external noise, etc. may amount to the same order of magnitude as the energy-related benefits are given. The cost–benefit analysis includes newly developed technologies that show large variations in prices due to pioneer market pricing, add-on of learning costs and risk components of the installers. Based on new empirical data on the present cost-situation and past techno-economic progress, the potential of future cost reduction was estimated applying the experience curve concept. The paper shows, for the first time, co-benefits and cost dynamics of energy efficiency investments, of which decision makers in the real estate sector, politics and administrations are scarcely aware.

Keywords: Marginal costs; Energy efficiency; Co-benefits

1. Introduction and scope

In Switzerland—like in many other countries of the temperate zone—large and mostly untapped energy efficiency[1] potentials lie, amongst others, in decreasing space heating requirements, which make up approx. 50% of the useful energy and approx. one-third of the final energy demand. Useful energy requirements for space heating of existing buildings could be reduced by approx. one-third to one-half compared to the present average value for the building stock and improvements by a factor of 5 or more can be achieved for new buildings (again compared to the average of the existing building stock) (see Ecofys, 2002; Avasoo, 1997; Kanton Zürich, 1998; Jakob et al., 2002; Binz et al., 2002; www.minergie.ch, 2003; SISH, 1997).

In view of the objectives of the Swiss CO_2 law, which consists of reducing fossil fuel associated CO_2 emissions in 2010 by 15% compared to those of 1990, this energy efficiency and CO_2 reduction potential is of great significance. These potentials concerning buildings, in particular residential buildings, are not only significant because they are so extensive, but also because of the presumed low cost of tapping these potentials. However, at present many house owners and builders undertaking refurbishments barely take advantage of this potential. Partly this is due to numerous barriers that still exist and partly due to different objective functions between private and public economy. With respect to the above-mentioned environmental goals, some additional costs might be acceptable for the public economy. But

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[1] In this paper, energy efficiency measures, energy efficiency investments, energy conservation, etc. are used as synonyms.

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from the private economy perspective, there might be a lack of profitability. This is especially the case if decision making is based on the level of investment costs (instead of annualised costs) or on short-term (energy price) considerations and if environmental aspects are excluded. In the market of rental flats (which is quite relevant in Switzerland), the investor-user-dilemma might be an obstacle for capital-intensive energy efficiency investments. Further reasons are incomplete information about cost and benefits, in particular co-benefits, lack of awareness and further socio-economic reasons (age, financial situation of the owners).

Indeed, building refurbishment with insulation[2] was (and still is) often neglected by house owners. Only one-quarter to one-third of the façade refurbishments carried out in the past 15 years included energy efficient refurbishment (Jakob et al., 2002). The remainder only received plaster repairs, or rather a new coat of paint. For roofs and windows, the share of energy efficient refurbishments is slightly greater. For windows, this is particularly the case. The last 15–25 years; window refurbishment mostly meant window replacement and due to great technological progress only noticeably improved windows were available. But overall there is still a very large potential for lowering energy requirements of the building stock, as the share of the construction components that are not yet improved with respect to energy efficiency is still between 30% and 80%, depending on the component (roofs, walls, windows, including cellar ceilings which are common in most of the single and multi-family houses in Switzerland in contrast to most of the EU countries). In addition, the building envelope is often not completely but only partly refurbished, as the inquiries and surveys carried out on building façade and roofing companies have shown. The energy requirements of refurbished buildings therefore generally do not decrease down to the low-energy consumption levels of new buildings. However, from a construction technology point of view, it is perfectly possible to reach this low level or even a lower level.[3] This has been shown by a multitude of buildings of 'MINERGIE' label[4] and 'Passivhaus (passivehouse)' standard[5] and P&D projects carried out in the last few years in Switzerland, Germany, Austria and other countries (see examples in Binz and Schneider, 2000; EMPA, 2003; ZEN, 2003).

Commonly given arguments for not fulfilling the complete energy efficiency potential are the energy paradox (Jaffe and Stavins, 1994), in particular inadequate tenancy laws (Metron, 1998), (temporary) budget constraints, insufficient knowledge of cost and benefits, etc. Often, investors, house owners or interest groups also refer to the poor economic profitability of energy efficiency measures, while on the other hand emphasis is laid on the extremely low-cost level of energy and environment-related improvements. Thus, an up to date, adequate and comprehensive economic assessment of energy efficiency measures with regard to the present and future costs and benefits of these options, as well as the shape of the marginal cost curve, form an important basis of information.

In addition to a differentiated updating of the present costs, the cost development of energy efficiency concerning building envelopes and heating systems is an important basis for long-term decision making. The future cost development is frequently an issue of new technologies, new materials and building concepts or processes. These partly include considerable learning potentials or potentials of serial production (economy of scale), which could, in future, reduce the costs of these new technologies and building concepts. So far, these cost dynamics have rarely been examined for the case of building envelopes. However, from a policy point of view, a comprehensive economic assessment should include this aspect of cost dynamics and how it can be influenced by policy instruments. Indeed, the literature reports on technological learning in many different fields and that policy instrument could make use of it by stimulating the learning and experience process to reach faster economic viability (see IEA, 2000; Neij, 1997). This paper takes up only very briefly, some results regarding technological learning in the

[2]In this paper the terms 'thermal insulation' or 'insulation' include—next to insulation of walls, roofs, etc. also more energy-efficient windows.

[3]Most construction elements (like walls, roofs, windows, celler ceilings, etc.) of existing buildings can be refurbished to achieve a similar thermal quality as today's new buildings, i.e. if insulation of 10–14 cm is added or the existing windows are replaced with such of glazing U-values of for instance 1.1 W/m^2 K. Most heat loss of the thermal bridges can be removed at similar specific costs as area elements and only few thermal bridges might only be refurbished at high specific cost, but the energy loss of the latter could be compensated by appling more insulation to area elements. Indeed, an insulation thickness of 20 cm or even more does not cause any technical difficulty and the architectural challenge can be met in most of the cases. If the whole building envelop is refurbished, specific space heating demand can be reduced to less than 150 MJ/m^{2}a, and to less than 150 MJ/m^{2}a, if attention is also paid to air renewal heat loss.

[4]Minergie (registered trademark) is a label of quality for new and retrofited buildings that combines both the goals of living and working comfort and low demand of non renewable energy per square meter. There is a certain freedom of choice whether to meet the target value by improving the energy efficiency of the envelop or whether to use more renewable energy or heat pumps. Specific weights are associated to the different energy carriers to make them comparable. The target value for residential building for heating, hot water and electricity for heating purpose or air exchange is 150 M/m^{2}a (see Binz et al. (2002) and www.minergie.ch or www.minergie.com (in English) for more details).

[5]The German passivehouse standard, limits the energy demand for heating to 15 kWh/m^{2}a. More restrictions are made on the tightness of the building, primary energy consumption and the required capacity. See more details on certification conditions on www.passivhaus-institut.de.